

37. (New) The creep resistant zirconium-based alloy of claim 1, wherein the outer annular layer in the cladding comprises Zircaloy-2.

38. (New) The creep resistant zirconium-based alloy of claim 21, wherein the inner annular layer in the cladding comprises a zirconium barrier layer.

39. (New) The creep resistant zirconium-based alloy of claim 21, wherein the outer annular layer in the cladding comprises Zircaloy-2.

40. (New) The creep resistant zirconium-based alloy of claim 30, wherein the inner annular layer in the cladding comprises a zirconium barrier layer.

41. (New) The creep resistant zirconium-based alloy of claim 30, wherein the outer annular layer in the cladding comprises Zircaloy-2.

REMARKS

Applicant thanks the Examiner for the attention accorded the present Application in the January 14, 2003 Advisory Action, in which claims 1-7 and 18-35 were pending. In the Advisory Action, it was noted that the amendments filed in response to the Final Office Action will not be entered because they raise new issues that would require further consideration and/or search, and they are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal.

In the Final Office Action, claims 8-17 were withdrawn from consideration as being drawn to a non-elected invention; claims 1-7 and 18-35 were objected to for minor informalities; claims 1-7, 18-25, 28 and 30-35 were rejected under 35 U.S.C. § 102(b) as being anticipated by Inagaki; claims 26 and 29 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Inagaki; and claim 27 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Inagaki in view of Cheadle.

By the foregoing amendments, claims 1-7 and 18-35 have been amended to more clearly specify the present invention. Specifically, these claims have been amended to clarify that the creep resistant zirconium-based alloy is a middle annular layer in the

cladding disposed between an inner annular layer in the cladding and an outer annular layer in the cladding. Additionally, new claims 36-41 have been added to further claim embodiments of Applicant's invention. No new matter has been added, and the amendments are fully supported throughout the specification, as more fully described below.

Claims 1-7 and 18-41 are now currently pending in this Application. Based on the above amendments, Applicants respectfully submit that the rejections to claims 1-7 and 18-35 have been overcome. Reconsideration of this Application is respectfully requested in view of the foregoing amendments and the following remarks, and allowance of claims 1-7 and 18-41 is respectfully requested.

Claim Objections

Claims 1-7 and 18-35 were objected to for containing minor informalities – i.e., the Examiner stated that “zirconium alloy” should be amended to state that the balance of the composition is zirconium, i.e., “zirconium-based alloy.” The claims have been amended so they read “[a] creep resistant zirconium-based alloy”¹ Furthermore, claim 21 has been amended to read “[a] creep resistant zirconium-based alloy comprising ... the balance being substantially zirconium”² Applicants submit that these amendments overcome this objection. As such, withdrawal of this objection is respectfully requested.

35 U.S.C. § 102(b) and 103(a) rejections

Claims 1-7, 18-25, 28 and 30-35 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Inagaki et al. Claims 26 and 29 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Inagaki et al. Claim 27 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Inagaki et al in view of Cheadle. Applicants respectfully

¹ Applicant's spec., claims 1-7 and 18-35.

² Applicant's spec., claim 21.

disagree with the Examiner's conclusion and submit that the present invention is neither anticipated by, obvious in view of, nor even suggested by, Inagaki and/or Cheadle.

As presently claimed in Applicants' independent claims, Applicants' invention comprises "[a] creep resistant zirconium-based alloy for use in nuclear fuel cladding ... wherein the zirconium-based alloy comprises a middle annular layer in the cladding disposed between an inner annular layer in the cladding and an outer annular layer in the cladding."³ These amendments are supported by Applicants' specification at page 7, lines 4-11, and in Figure 1A, among other places.

In contrast, Inagaki does not disclose a zirconium-based alloy for use as a middle annular layer in an annularly layered fuel cladding. Inagaki's invention comprises "a nuclear fuel cladding tube made of a zirconium-based alloy."⁴ Inagaki mentions only that "the nuclear fuel cladding tube of the invention is made of the zirconium-based alloy of the invention,"⁵ and never mentions that these tubes could comprise annular layers of materials as claimed in Applicants' invention. Therefore, Inagaki does not anticipate, nor even suggest, a creep resistant zirconium-based alloy for use as a middle annular layer in an annularly layered fuel cladding, as recited in independent claims 1, 21 and 30 of Applicants' invention.

Cheadle fails to cure the deficiencies of Inagaki. Cheadle does not disclose a zirconium-based alloy for use as a middle annular layer in an annularly layered fuel cladding either. Cheadle discloses "zirconium alloy tubes especially for use in nuclear applications."⁶ Furthermore, Cheadle discloses that these tubes are extruded,⁷ and never mentions that these tubes could comprise annular layers of materials as claimed in Applicants' invention. Thus, Cheadle does not disclose, nor even suggest, a creep resistant zirconium-based alloy for use as a middle annular layer in an annularly layered fuel cladding, as recited in independent claims 1, 21 and 30 of Applicant's invention.

Based on the above arguments and amendments, Applicants respectfully submit that independent claims 1, 21 and 30 of the present invention are patentably distinguished

³ Applicant's spec., independent claim 1. *See also* Applicant's spec., independent claims 21 and 30 which are similar.

⁴ Inagaki, independent claims 1, 3, 5 and 7.

⁵ Inagaki, col. 5, lines 7-12.

⁶ Cheadle, col. 1, lines 5-6.

⁷ Cheadle, col. 1, lines 8-38; col. 3, lines 26-47; and claim 1.

from Inagaki. As claims 2-7 and 18-20 depend from claim 1, claims 22-29 depend from claim 21, and claims 31-35 depend from claim 30, the discussion above applies to these claims as well. Further, these claims each include separate novel features. Thus, Applicants respectfully request allowance of pending claims 1-7 and 18-35.

New Claims

Applicants have also added new claims 36-41 to further define the present invention. No new matter has been added and these claims are fully supported by Applicants' specification at page 7, lines 4-11; and in Figure 1, among other places. Therefore, allowance of claims 36-41 is respectfully requested.

CONCLUSION

Applicants respectfully submit that the amendments to the claims successfully traverse the rejections and objections given by the Examiner in the Final Office Action. For the above reasons, it is respectfully submitted that the claims now pending patentably distinguish the present invention from the cited references. Allowance of pending claims 1-7 and 18-41 is therefore respectfully requested. Additionally, Applicants respectfully request that non-elected claims 8-17 be rejoined and allowed too.

As this request for continued examination ("RCE") is being timely filed within 3 months of the mailing date of the Final Office Action, Applicants believe that there is no fee due for this response except for the filing of the new claims (6 new claims in excess of 20 at \$18 each). Payment in the amount of **\$108** is enclosed. If this amount is incorrect, the Commissioner is authorized to charge any additional fees that may be due, or credit any overpayment, to **Deposit Account No. 04-1448**.

Should the Examiner have any questions, or determine that any further action is necessary to place this Application into better form for allowance, the Examiner is encouraged to telephone the undersigned representative at the number listed below.

Respectfully submitted,

Date: 01/28/03


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VERSION WITH MARKINGS TO SHOW CHANGES MADE

Amendments in the Specification:

In accordance with 37 C.F.R. § 1.121(b), the following replacement paragraphs show all of the changes made by the foregoing amendments relative to the previous versions of the paragraphs. Material added is shown underlined, material deleted is shown in [brackets].

Please amend the fourth full paragraph on page 8 as follows:

Two plates of Zircaloy-2 were compared. Plate A was cold rolled 51 % from an as-hot rolled Zircaloy-2 plate nominally one inch thick. Plate B was cold rolled 36% from a second one inch thick plate which was beta heat treated and quenched before cold rolling. Following cold rolling, both plates were given a 3 hr heat treatment in Ar gas at 620°C. Plate A had a uniform fine recrystallized grain structure. Plate B had a coarse grained lath alpha-zirconium microstructure in part of the plate thickness and a recrystallized grain structure in the remainder. Zircaloy-2 has a low volume fraction of second phase particles that contribute to the plastic deformation [behaviour] behavior and corrosion resistance of the alloy. The mean second phase particle diameter of Plate A was 0.20 μ m. The mean second phase particle diameter of Plate B was 0.075 μ m.

Amendments in the Claims:

In accordance with 37 C.F.R. § 1.121(c)(1), the following replacement claims show all of the changes made by the foregoing amendments relative to the previous versions of the claims. Material added is shown underlined, material deleted is shown in [brackets].

1. (Amended) A creep resistant [zirconium] zirconium-based alloy for use in nuclear fuel cladding, wherein the zirconium-based alloy comprises [comprising] a coarse grained lath alpha microstructure[.], and wherein the zirconium-based alloy comprises a middle annular layer in the cladding disposed between an inner annular layer in the cladding and an outer annular layer in the cladding.
2. (Twice Amended) The [zirconium] zirconium-based alloy as claimed in claim 1 wherein the microstructure comprises second phase precipitates.
3. (Twice Amended) The [zirconium] zirconium-based alloy as claimed in claim 2 wherein the second phase precipitates have a diameter less than about $0.15\mu\text{m}$.
4. (Amended) The [zirconium] zirconium-based alloy as claimed in claim 3 wherein the microstructure is partially recrystallized.
5. (Amended) The [zirconium] zirconium-based alloy as claimed in claim 4 wherein the microstructure is less than 50% recrystallized.
6. (Twice Amended) The [zirconium] zirconium-based alloy as claimed in claim 1 wherein the microstructure has an acicular structure comprising a lath spacing within the range from about $0.5\mu\text{m}$ to about $3.0\mu\text{m}$.
7. (Twice Amended) The [zirconium] zirconium-based alloy as claimed in claim 5 wherein the microstructure is an acicular structure and comprises a lath spacing within the range from about $0.5\mu\text{m}$ to about $3.0\mu\text{m}$.

18. (Amended) The [zirconium] zirconium-based alloy as claimed in claim 2 wherein the second phase precipitates have a diameter less than about 0.10 μm .

19. (Amended) The [zirconium] zirconium-based alloy as claimed in claim 2 wherein the second phase precipitates have a mean particle diameter of about 0.075 μm .

20. (Amended) The [zirconium] zirconium-based alloy as claimed in claim 2 wherein the second phase precipitates comprise at least one of Fe and Cr.

21. (Amended) A creep resistant [zirconium] zirconium-based alloy for use in nuclear fuel cladding, said alloy comprising a coarse grained lath alpha microstructure, said alloy comprising approximately 1.2-1.7 weight percent Sn, approximately 0.13 to less than 0.20 weight percent Fe, approximately 0.06-0.15 weight percent Cr, approximately 0.05-0.08 weight percent Ni, and the balance being substantially [Zn;] zirconium, said alloy having been subjected to a predetermined treatment[.], and said alloy comprising a middle annular layer in said cladding disposed between an inner annular layer in the cladding and an outer annular layer in the cladding.

22. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 21, wherein the predetermined treatment comprises:

beta heat treating a [zirconium] zirconium-based alloy to form a first intermediate;

fast quenching the first intermediate to form a second intermediate;

cold working the second intermediate to form a third intermediate; and

annealing the third intermediate to effect partial recrystallization of the microstructure.

23. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 22, wherein the cold working step further comprises cold working the second

intermediate within the range from about 30% to about 40% to form the third intermediate.

24. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 22, wherein the cold working step further comprises cold working the second intermediate about 36% to form the third intermediate.

25. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 22, wherein the beta heat treating step occurs at a temperature above about 965°C.

26. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 22, wherein the beta heat treating step has a duration of from about 1 second to about 10 seconds.

27. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 22, wherein the fast quenching step is conducted at a cooling rate within the range from about 20°C/second to about 200°C/second.

28. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 22, wherein the annealing step is conducted within the temperature range of from about 570°C to about 640°C.

29. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 22, wherein the annealing step is conducted at about 620°C for about 3 hours.

30. (Amended) A creep resistant [zirconium] zirconium-based alloy for use in nuclear fuel cladding, said alloy comprising a coarse grained lath alpha microstructure comprising second phase precipitates, wherein the microstructure of the alloy is partially recrystallized after being subjected to a treatment comprising beta heat treating the alloy to form a first intermediate, fast quenching the first intermediate to form a second intermediate, cold working the second intermediate to form a third intermediate[;], and

then annealing the third intermediate to effect partial recrystallization of the microstructure[.], wherein the alloy comprises a middle annular layer in the cladding disposed between an inner annular layer in the cladding and an outer annular layer in the cladding.

31. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 30, wherein the second phase precipitates have a diameter less than about $0.15\mu\text{m}$.

32. (Amended) The [zirconium] creep resistant zirconium-based alloy as claimed in claim 30, wherein the second phase precipitates have a mean particle diameter of about $0.075\mu\text{m}$.

33. (Amended) The [zirconium] creep resistant zirconium-based alloy as claimed in claim 30, wherein the second phase precipitates comprise at least one of Fe and Cr.

34. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 30, wherein the microstructure is less than 50% recrystallized.

35. (Amended) The creep resistant [zirconium] zirconium-based alloy of claim 30, wherein the microstructure has a acicular structure comprising a lath spacing within the range from about $0.5\mu\text{m}$ to about $3.0\mu\text{m}$.